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END PORTION FOR A FLEXIBLE FLUID CONTAINMENT VESSEL AND A METHOD OF MAKING THE SAME

Field of the Invention

The present invention relates to a flexible fluid containment vessel (sometimes hereinafter referred to as "FFCV") for transporting and containing a large volume of fluid, particularly fluid having a density less than that of salt water, more particularly, fresh water, and a method of making the same.

Background of the Invention

The use of flexible containers for the containment and transportation of cargo, particularly fluid or liquid cargo, is known. It is well known to use containers to transport fluids in water, particularly, salt water.

If the cargo is fluid or a fluidized solid that has a density less than salt water, there is no need to use rigid bulk barges, tankers or containment vessels. Rather, flexible containment vessels may be used and towed or pushed from one location to another. Such flexible vessels have obvious advantages over rigid vessels. Moreover, flexible vessels, if constructed appropriately, allow themselves to be rolled up or folded after the cargo has been removed and stored for a return trip.

Throughout the world there are many areas which are in critical need of fresh water. Fresh water is such a commodity that harvesting of the ice cap and icebergs is rapidly emerging as a large business. However, wherever the fresh water is obtained, economical transportation thereof to the intended destination is a concern.

For example, currently an icecap harvester intends to use tankers having 150,000 ton capacity to transport fresh water. Obviously, this involves, not only the cost in using such a transport vehicle, but the added expense of its return trip, unloaded, to pick up fresh cargo. Flexible container vessels, when emptied can be collapsed and stored on, for example,

the tugboat that pulled it to the unloading point, reducing the expense in this regard.

Even with such an advantage, economy dictates that the volume being transported in the flexible container vessel be sufficient to overcome the expense of transportation. Accordingly, larger and larger flexible containers are being developed. However, technical problems with regard to such containers persist even though developments over the years have occurred. In this regard, improvements in flexible containment vessels or barges have been taught in U.S. Patents 2, 997,973; 2,998,973; 3,001,501; 3,056,373; and 3,167,103. The intended uses for flexible containment vessels is usually for transporting or storing liquids or fluidisable solids which have a specific gravity less than that of salt water.

The density of salt water as compared to the density of the liquid or fluidisable solids reflects the fact that the cargo provides buoyancy for the flexible transport bag when a partially or completely filled bag is placed and towed in salt water. This buoyancy of the cargo provides flotation for the container and facilitates the shipment of the cargo from one seaport to another.

In U.S. Patent 2,997,973, there is disclosed a vessel comprising a closed tube of flexible material, such as a natural or synthetic rubber impregnated fabric, which has a streamlined nose adapted to be connected to towing means, and one or more pipes communicating with the interior of the vessel such as to permit filling and emptying of the vessel. The buoyancy is supplied by the liquid contents of the vessel and its shape depends on the degree to which it is filled. This patent goes on to suggest that the flexible transport bag can be made from a single fabric woven as a tube. It does not teach, however, how this would be accomplished with a tube of such magnitude. Apparently, such a structure would deal with the problem of seams. Seams are commonly found in commercial flexible transport bags, since the bags are typically made in a patch work manner with stitching or other means of connecting the patches of water proof material together. See

e.g. U.S. Patent 3,779,196. Seams are, however, known to be a source of bag failure when the bag is repeatedly subjected to high loads. Seam failure can obviously be avoided in a seamless structure. However, since a seamed structure is an alternative to a simple woven fabric and would have different advantages thereto, particularly in the fabrication thereof, it would be desirable if one could create a seamed tube that was not prone to failure at the seams.

In this regard, U.S. Patent No. 5,360,656 entitled "Press Felt and Method of Manufacture", which issued November 1, 1994 and is commonly assigned, the disclosure of which is incorporated by reference herein, discloses a base fabric of a press felt that is fabricated from spirally wound fabric strips.

The length of fabric will be determined by the length of each spiral turn of the fabric strip of yarn material and its width determined by the number of spiral turns.

An edge joint can be achieved, e.g. by sewing, melting, and welding (for instance, ultrasonic welding as set forth in U.S. Patent No. 5,713,399 entitled "Ultrasonic Seaming of Abutting Strips for Paper Machine Clothing" which issued February 3, 1998 and is commonly assigned, the disclosure of which is incorporated herein by reference) of non-woven material or of non-woven material with melting fibers.

While that patent relates to creating a base fabric for a press felt such technology may have application in creating a sufficiently strong tubular structure for a transport container. Moreover, with the intended use being a transport container, rather than a press fabric where a smooth transition between fabric strips is desired, this is not a particular concern and different joining methods (overlapping and sewing, bonding, stapling, etc.) are possible. Other types of joining may be apparent to one skilled in the art.

Furthermore, while as aforenoted, a seamless flexible container is desirable and has been mentioned in the prior art, the means for manufacturing such a structure has its difficulties. Heretofore, as noted,

large flexible containers were typically made in smaller sections which were sewn or bonded together. These sections had to be water impermeable. Typically such sections, if not made of an impermeable material, could readily be provided with such a coating prior to being installed. The coating could be applied by conventional means such as spraying or dip coating.

Another problem is how to seal the end of the container, especially where tapering at the end is desired. End portions can be made separately and attached to the tubular structure, examples of which are set forth in the aforesaid applications and the references cited therein. It may also be desirable to have the end portions formed out of the tubular structure itself and formed into a desired shape (i.e. cone shaped etc.). In this regard, for example, U.S. Patent No. 2,997,973 issued on August 29, 1961 to Hawthorne shows the use of pleating of the fabric at the ends which are then glued and/or sewn to provide the desired shape.

Accordingly, there exists a need for a FFCV for transporting large volumes of fluid which overcomes the aforenoted problems attendant to such a structure and the environment in which it is to operate.

Summary of the Invention

It is therefore a principal object of the invention to provide for a relatively large fabric FFCV for the transportation of cargo, including, particularly, fresh water, which has means of sealing the ends thereof in a desired manner.

It is a further object of the invention to provide means for sealing the ends of such an FFCV in conjunction with a tapering of the ends thereof.

A further object of the invention is to provide for a means for sealing the ends of such an FFCV so as to effectively distribute the load thereon.

These and other objects and advantages will be realized by the present invention. In this regard the present invention envisions the use of a woven, spirally formed or segmented tube to create the FFCV, having a length of 300 feet or more and a diameter of 40 feet or more. Such a large

structure can be fabricated on machines that make papermaker's clothing. The ends of the tube, sometimes referred to as the nose and tail, or bow and stern, may be sealed by a number of means. End portions may be affixed to the tube, spirally formed or otherwise formed out of the tube itself. The present invention is directed towards a particular configuration for the end portions. In the case of a tube formed having a large uniform circumference of perhaps 130 to 245 feet or more, it would be necessary, however, to reduce the circumference down to a manageable size so as to allow an end cap or tow member to be affixed thereto. While doing so, it is desirable to taper the end portion tube such as that of a cone or the bow of a ship, while maintaining a unitized construction.

Once the end of the tube of the FFCV is reduced to a manageable circumference, an end closure mechanism is then affixed thereto. In this regard, the end closure mechanism comprises two interlocking parts each with conforming conical or curved surfaces between which the fabric is clamped. The mechanism, in addition to sealing the end of the FFCV, would also include interface features such as fluid flow ports for loading and unloading cargo along with a coupling mechanism for such loading and unloading. A towing hitch may also be part of this mechanism.

Brief Description of the Drawings

Thus by the present invention its objects and advantages will be realized, the description of which should be taken in conjunction with the drawings, wherein:

Figure 1 is a somewhat general perspective view of a known FFCV which is cylindrical having a pointed bow or nose;

Figure 2 is a somewhat general perspective view of a FFCV which is cylindrical having a flattened bow or nose;

Figure 3 is a side sectional view of the end closure mechanism incorporating the teachings of the present invention; and

Figure 4 is a partial prospective view of an FFCV with the mechanism as shown in Figure 3, incorporating the teachings of the present invention.

Detailed Description of the Preferred Embodiment

The FFCV 10 generally is intended to be constructed of an impermeable textile tube. While the tube or tubular structure 12 configuration may vary, the tube is shown generally (in Figure 1) as being cylindrical having a substantially uniform diameter (perimeter) and then closed and sealed on each end 14 and 16. The respective ends 14 and 16 may be closed in any number of ways. As will be discussed it is a particular way of doing so to which the present invention is directed. The resulting impermeable structure should also be flexible enough to be folded or wound up for transportation and storage.

In designing the FFCV to withstand the loads placed thereon, certain factors should be considered. In this regard, in co-pending U.S. Patent Application Serial No. 09/832,739 filed April 11, 2001 entitled "Flexible Fluid Containment Vessel" such factors are set forth in detail, along with possible materials for the fabric, its construction and possible coatings and methodology to apply to it to render the fabric impermeable, in addition to other features which may be desirable with regard to the FFCV. Accordingly, further discussion thereof will not be repeated herein rather reference is made to said application.

Also, the present device may have application with regard to the spiral formed FFCV as disclosed in co-pending U.S. Patent Application Serial No. 09/908,877 filed July 18, 2001 entitled "Spiral Formed Flexible Fluid Containment Vessel".

In addition, reference is made to U.S. Patent Application Serial No. 09/921,617 filed August 3, 2001 entitled "End Portions for a Flexible Fluid Containment Vessel and a Method of Making the Same" which relates to possible construction of the end portions of the FFCV to which the present

invention is directed to the particular configuration disclosed herein. Also, U.S. Patent Application Serial No. 09/923,936 filed August 7, 2001 entitled "Coating for a Flexible Fluid Containment Vessel and a Method of Making the Same" discloses additional constructions for the fabric in addition to possible coatings therefor.

While the aforesaid patent applications discuss the various forces important in the design of the FFCV, the present application is directed toward a particular means for closing the bow and/or stern of an FFCV. The present invention envisions a tapered structure so as to reduce the circumference to a manageable size by pleating or other means as disclosed in application Serial Number 09/921,617.

The FFCV 10 includes a tube 12 and end portions generally designated 14 for the bow and 16 for the stern (not shown in Figure 4). The construction shown allows one to convert a tube 12 into a cone shaped bow 14 and/or a cone shaped stern 16. Pleating, folding or other means disclosed in Serial Number 09/921,617 allows one to convert the end of the tube 12 into a smaller diameter. The pleats 18, for example, may be formed about the circumference of the tube 12 so as to allow for the end of the tube 12 to become tapered or having a reduced circumference as shown in Figure 4.

With this in mind, we turn now to the construction of the end closure mechanism 30 which can be used to close either or both ends of the FFCV. The mechanism 30 comprises two interlocking portions. There is a front or outward portion 32 and a rear or internal portion 34. The fabric 20 making up the tubular structure of the FFCV 10 would be pleated at the bow (and/or the stern) as shown generally by pleats 18 in Figure 4. Portion 34 would be within the FFCV 10 and is circular in shape. It includes a continuous sealing ring 36 which is mounted upon a spider support member 38. Member 38 comprises a plurality of spokes or vanes 40 coupling ring 36 to an axial hub 42. Vanes 40 allow fluid to pass through portion 34 during the filling and emptying of the FFCV. Portion 34 is preferably made of a material which will not interact with the cargo which, depending upon its constituent, may

be a high strength metal (i.e. stainless steel) or reinforced composite and is fabricated as a single piece.

Ring 36 includes a conical or curve portion 44 at its end. This curve portion 44 is intended to clamp fabric 20 against portion 32. In this regard, portion 32 includes a circular ring receiving portion 46. Portion 46 includes an annular curved or beveled surface 48 for matingly engaging curved portion 44 of ring 36. Located in the center of portion 32 is a clamping screw receiving member 50. In this regard, a clamping screw 52 is provided which passes through hub 42 and an axial opening 53 in member 50. A threaded portion 54 of screw 52 receives a nut 56 which is threaded down after the fabric 20 is positioned between portion 44 and surface 48.

After the tubular portion of the FFCV is appropriately pleated and the pleats sealed or otherwise bonded in place so as to reduce the end to the proper circumference, the clamping mechanism 30 is then placed thereon. Portion 44 and surface 48 create conforming conical surfaces between which the fabric is clamped. The tightening of screw 52 generates a seal between two sides of the fabric which is able to withstand a substantial pressure differential and prevents egress of fluid (e.g. from the inside 58 to outside 60 of the FFCV). If necessary, a sealant may also be used in this area to ensure that a sealing has occurred. The conical geometry generates higher compressive load in the fabric than a simple flat plate would with the same axial load and has a self-centering tendency when loaded.

The curved portion 44 of ring 36 protrudes into the higher pressure side (interior 58) of the fabric so that increasing fluid pressure gives rise to increasing sealing force between the fabric and surface 48. The curved portions are diverging and impart a gentle transition geometry which results in reduced stress concentrations in the fabric and improve durability of the fabric.

Note, the use of relief radii in the unclamped region of the mechanism 30 may also reduce localized tight geometry changes for a range of loading and movement conditions.

The required clamping force is generated by the application of simple linear load by a load bearing member or clamping screw 52. Other types of devices may also be used such as spring clamp with air or hydraulic release or an over-center locking device or other means suitable for the purpose.

Note that, since portion 32 will also be in contact with the cargo, it too, as well as any other components or surfaces in contact with the cargo, should be made of a material that does not interact with the cargo which, depending upon the constituent thereof, may be as aforesaid, high strength metal (i.e. stainless steel) or a reinforced composite material. Portion 32 has a number of fluid flow ports 62. These may be defined by vanes (not shown) which connect member 50 to ring receiving portion 46. In addition, portion 32 includes a tubular extension 64 having its interior in fluid communication with the fluid flow ports 62. Such extension 64 may be so configured to provide for sealing and porting with a filling or emptying device. A capping device 66 is affixed sealing the extension 64 off which may be opened to allow for filling or emptying of the cargo. A towing hitch 68 may be affixed to cap 66 or at other locations on the clamping mechanism 30 for securing a tow cable. This, of course, is only for illustration purposes and appropriate configuration and location(s) thereof will be apparent to one skilled in the art.

The aforesaid clamping mechanism has apparent attendant advantages. These include the ability to increase pressure on the fabric by the tightening of the load bearing member so as to increase the clamping force, if necessary. Also, reduced stress concentrations on the fabric are due to the relatively gentle geometry changes between the surfaces providing the clamping. Conventional sealing and hook up equipment may readily be incorporated, if necessary. In addition, the clamping surfaces can be modified for different applications. For example, it can be very shallow for flat surfaces of the fabric and more acute for higher compression loads or where elasticity of the fabric is a factor. Also, the configuration of the clamping mechanism may be such that the towing force thereon might be

used to add to the clamping force generated, as will be apparent to one skilled in the art.

Although a preferred embodiment has been disclosed and described in detail herein, its scope should not be limited thereby; rather its scope should be determined by that of the appended claims.